

siderable reduction in heat gain, if all factors except solar intensity remain the same. Reference 22 gives heat gain values for four orientations at 40 deg north latitude on August 1 for several types of flat glass and glass block, and solar intensities typical of humid industrial atmospheres. These data show that the following approximate reductions, based on total gain for the day, can be expected: 20 percent for all types of glass and glass block in east or west facing walls; 10 percent for south facing flat glass; 5 percent for south facing glass block walls.

Shading of Glass Areas—Design Tables

The effects and possibilities of shading should be carefully investigated whenever the heat gain from glass is a large portion of the cooling load.

Vertical glass, which is not mounted in the plane of the building surface, is partially shaded by the setback. If a vertical window of height l and width w be set back from the plane of the building a distance s , the fraction of the total area of the window which receives direct solar radiation is:

$$G_t = 1 - \frac{r_1 \tan \beta}{\cos \gamma} - \frac{r_2 \tan \gamma}{\cos \gamma} + \frac{r_1 r_2 \tan \beta \tan \gamma}{\cos \gamma} \quad (5)$$

where

$r_1 = s/l$, $r_2 = s/w$, β = solar altitude, and γ is the wall solar azimuth (see Fig. 1).

Values of β and γ for various latitudes and August 1 are given in Table 6. Special cases not covered by the tabulated data may be solved analytically,²⁴ however, the design conditions chosen will yield a satisfactory approximation if used without correction for any time during the summer period.

Example 11: Estimate the total instantaneous rate of heat gain for a west window 3 ft wide by 5 ft high, with a setback of 6 in., for August 1 and 40 deg north latitude at 3:00 pm (sun time).

Solution: From Table 13, the instantaneous rate of heat gain, due to transmitted direct and diffuse solar radiation, is 180 Btu per hr. From Table 6, β is 45.5 deg and γ is 16 deg. From Equation 5, the fraction of the total window area that is receiving direct solar radiation is:

$$G_t = 1 - \frac{0.1 \tan 45.5}{\cos 16} - \frac{0.167 \tan 16}{\cos 16} + \frac{0.0167 \tan 45.5 \tan 16}{\cos 16} \\ = 1 - 0.106 - 0.048 + 0.005 = 0.851$$

In this instance the convection and radiation heat gain is due principally to temperature difference, so that shading has but a small effect on that portion of the absorbed radiation. Hence, the factor 0.851 is applied only to the Table 13 value. Note also a small error results from the fact that the diffuse radiation is not shaded to the same extent as the direct radiation. The total instantaneous heat gain therefore is:

$$q = 3 \times 5 (0.851 \times 180 + 26) = 2690 \text{ Btu per (hr)(sq ft)}$$

A window such as the one used in Example 11 would customarily be provided with an additional shading means for use particularly when directly sunlit. Conventional shading devices include awnings, shades, and screens of various types.

Recent experimental and analytical work conducted at the A.S.H.V.E. Research Laboratory²⁵ as well as earlier experimental work,^{24, 26} and other research²⁷ to determine the effectiveness of various types of window shades

have been used as the basis for the recommended ratios in column 3 of Table 24. A study of absorptivity of the shade to solar radiation and heat transfer from the shade to the outdoors and indoors, was used to determine these ratios.

There are a number of variables affecting these ratios such as color, fit, solar altitude, and angle of incidence of the solar radiation. These values,

TABLE 24. EFFECT OF SHADING UPON INSTANTANEOUS SOLAR HEAT GAIN THROUGH SINGLE THICKNESS OF COMMON WINDOW GLASS

TYPE OF SHADING	FINISH ON SIDE EXPOSED TO SUN	FRACTION OF GAIN THROUGH UNSHADOWED WINDOW
Canvas awning sides open		
Canvas awning top and sides tight against building	Dark or medium	0.25
Inside roller shade, fully drawn ^a	Dark or medium	0.35
Inside roller shade, fully drawn ^a	White, cream	0.41
Inside roller shade, fully drawn ^a	Medium	0.62
Inside roller shade, fully drawn ^a	Dark	0.81
Inside roller shade, half drawn ^a	White, cream	0.71
Inside roller shade, half drawn ^a	Medium	0.81
Inside roller shade, half drawn ^a	Dark	0.91
Inside venetian blind, slats set at 45 deg ^b	White, cream	0.56
Inside venetian blind, slats set at 45 deg ^b	Diffuse reflecting aluminum metal	0.45
Inside venetian blind, slats set at 45 deg ^b	Medium	0.65
Inside venetian blind, slats set at 45 deg ^b	Dark	0.75
Outside venetian blind, slats set at 45 deg ^b	White, cream	0.15
Outside venetian blind, slats set at 45 deg ^b	White, cream	0.15
Outside venetian blind, slats set at 45 deg, extended as awning covering 3/4 of window ^c	White, cream	0.43
Outside shading screen solar altitude 10 deg	Dark ^{d, f}	0.52
Outside shading screen solar altitude 20 deg		0.40
Outside shading screen solar altitude 30 deg		0.25
Outside shading screen solar altitude, above 40 deg		0.15
	Green tint ^{e, f}	0.46
		0.35
		0.22

^a Roller shades are assumed to be opaque. Some white shades may transmit considerable solar radiation. For white translucent shades fully drawn use 0.55 and for half drawn use 0.77.

^b Venetian blinds are fully drawn and cover window. It is assumed that the occupant will adjust slats to prevent direct rays from passing between slats. If slats are fully closed (slats set at 90 deg.) use same factors as used for roller shade fully drawn.

^c Commercial shade with wide slats. The sun may shine on window through sides of shade. Estimate the exposed portion of glass as unshaded.

^d Commercial shade, bronze. Metal slats 0.05 inches wide 17 per inch and set at 17 deg angle with horizontal. At solar altitudes below 40 deg some direct solar rays are allowed to pass between slats, and this amount becomes progressively greater at low solar altitudes.

^e Commercial aluminum shade. Slats 0.057 inches wide, 17.5 per inch, set at 17 deg angle with horizontal. At solar altitudes below 40 deg some direct solar rays are allowed to pass between slats and this amount becomes progressively greater at low solar altitude.

^f From first paper in Reference 9.

therefore, must be considered as approximate, only, and will have to be used with considerable judgment. An inside shade is effective to the extent of its reflectivity, since the portion of the solar radiation directly transmitted by the glass that is absorbed by the shade is transferred by convection to the room air, and by radiation to the solid room surfaces.

INSTANTANEOUS HEAT GAINS VS. INSTANTANEOUS COOLING LOADS

The difference between instantaneous heat gain and instantaneous cooling load has been mentioned previously; its practical importance is suffi-